

(21) Application No 0307412.7

(22) Date of Filing 31.03.2003

(30) Priority Data

(31) 10116888

(32) 05.04.2002

(33) US

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(51) INT CL⁷

G01R 31/36

(52) UK CL (Edition V)

G1U UR3136

U1S S2123 S2215 S2219

(56) Documents Cited

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US 6215275 A

US 6134457 A

US 6046574 A

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(58) Field of Search

UK CL (Edition V) G1U

INT CL⁷ G01R

Other: Online: EPODOC, WPI, PAJ

(54) Abstract Title

Battery charge level measuring in an appliance

(57) A battery-operated appliance contains a battery charge level measuring circuit for determining the status of the battery. The appliance has several operating modes, each requiring a different power level from the battery. To obtain an accurate measurement of battery charge level in a given operating mode, a battery characteristic such as terminal voltage is allowed to stabilise for a recovery time before a measurement is taken. The recovery time is dependent on the operating mode of the appliance. The battery charge level measurement may be used to disable certain modes of the appliance, if it is determined that there is insufficient power to perform that mode.

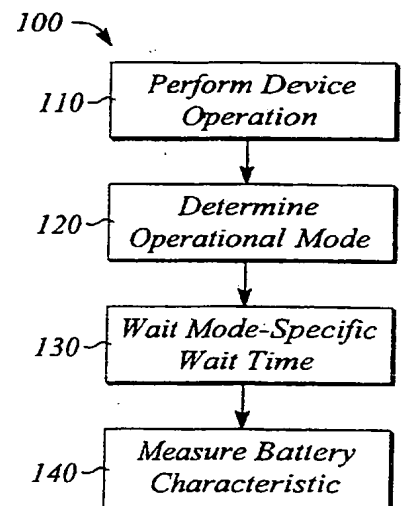


FIG. 1

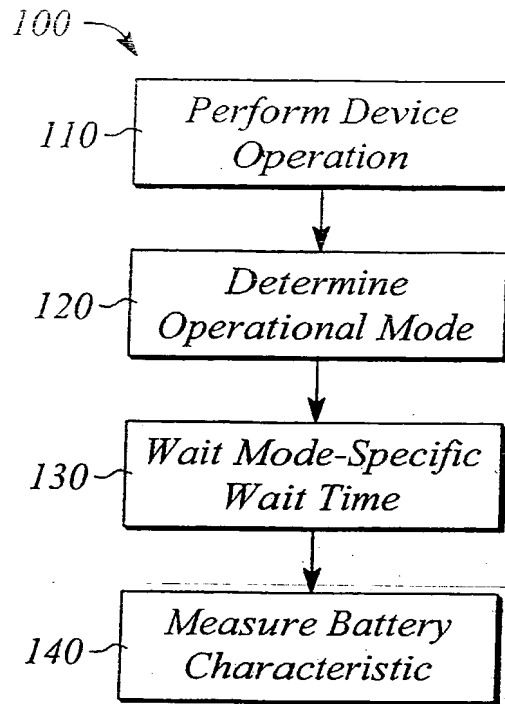


FIG. 1

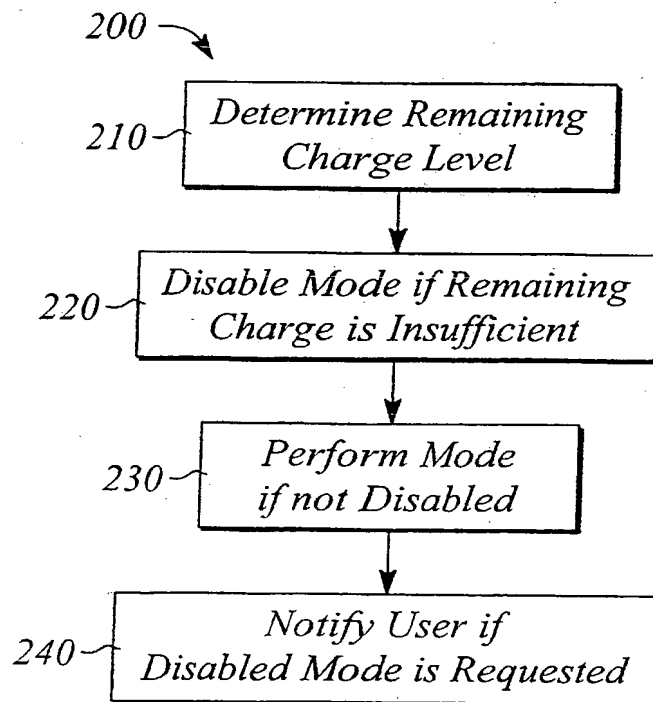


FIG. 2

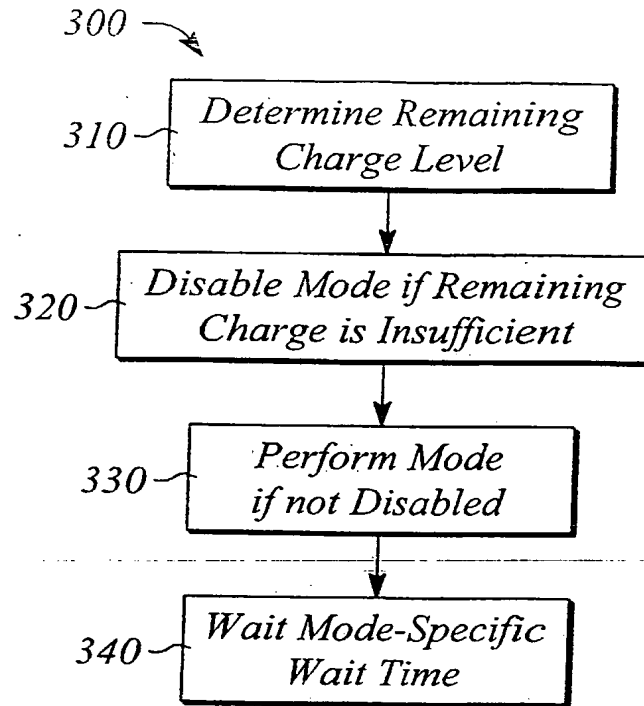


FIG. 3

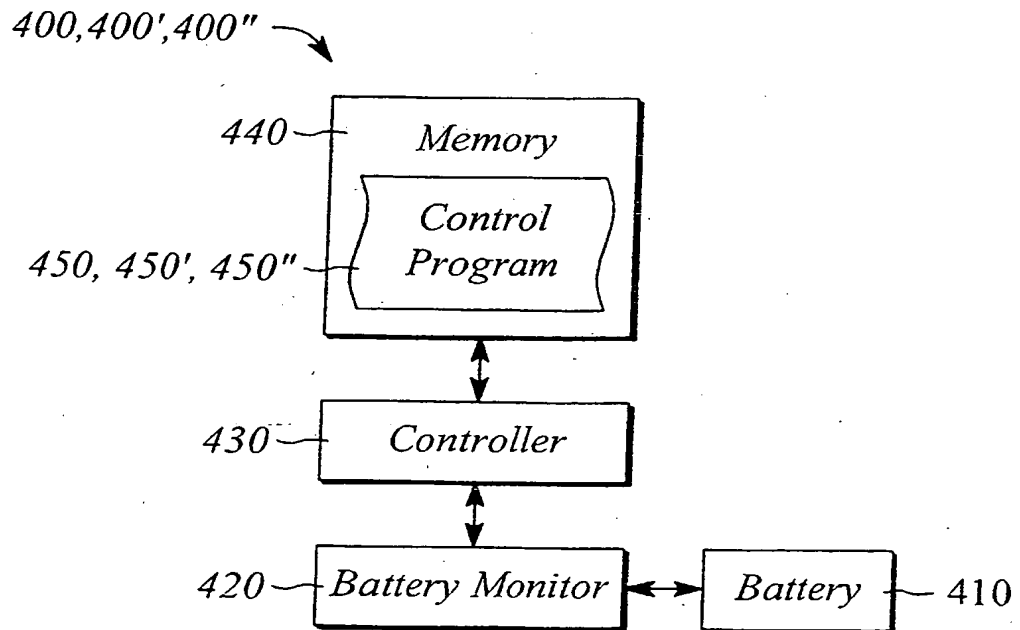


FIG. 4

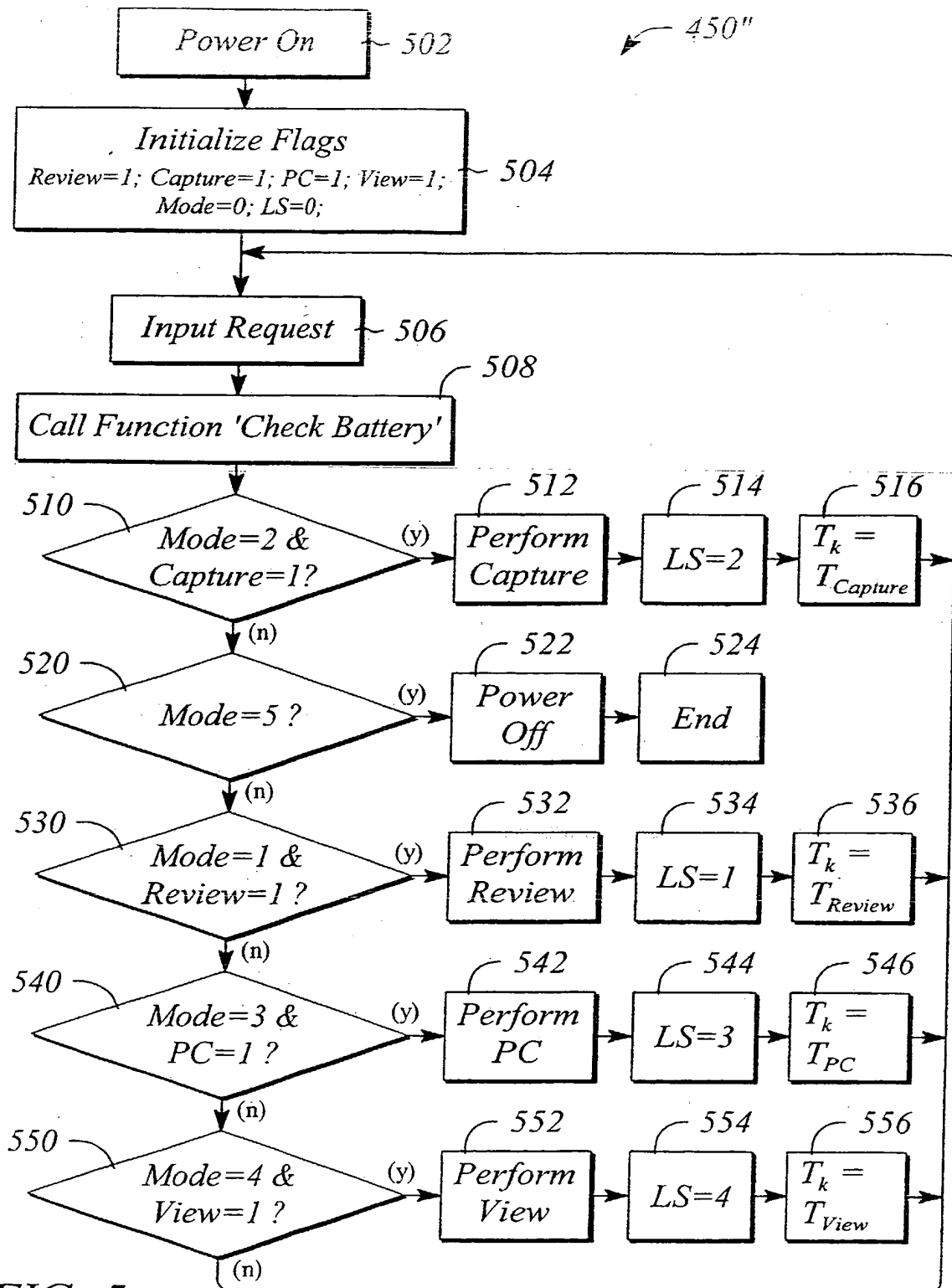


FIG. 5

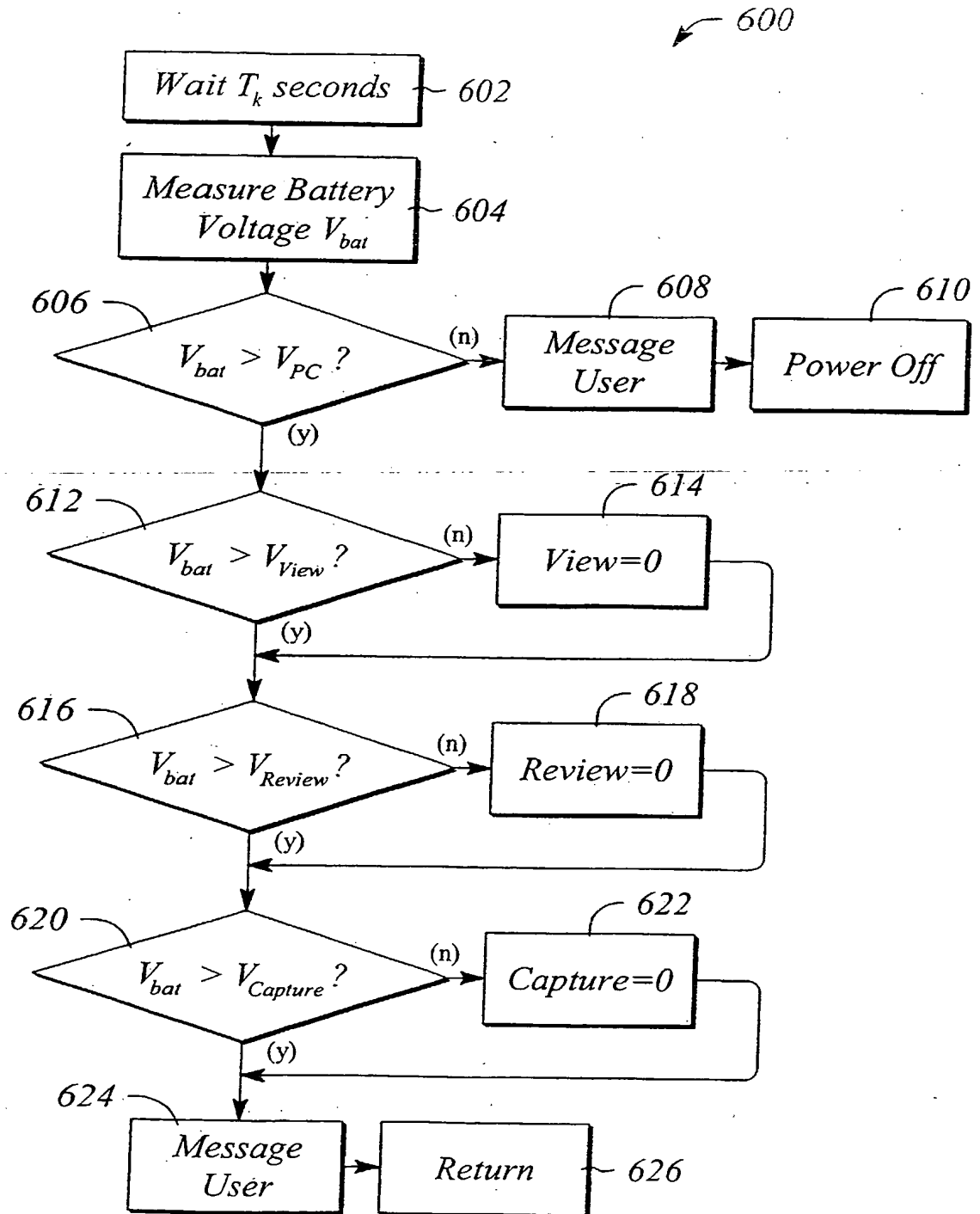


FIG. 6

OPERATIONAL MODE-BASED BATTERY MONITORING FOR A BATTERY-POWERED ELECTRONIC DEVICE

TECHNICAL FIELD

This invention relates to battery-powered devices. In particular, the invention
5 relates to *in-situ* monitoring of a remaining charge level in and determining a cut-off
point for a battery of a battery-powered device.

BACKGROUND ART

Battery-powered electronic devices, electronic devices that derive some or all of
their operating power from one or more batteries, are popular, widely available and in
10 relatively widespread use. In particular, electronic devices that use batteries as a
primary operational power source are able to be portable and mobile, such that the
devices are effectively free from a fixed location and power source. In many
instances, portability is responsible for much of the market share attributed to such
devices. Examples of popular battery-powered electronic devices include, but are not
15 limited to, notebook and laptop computers, hand-held computers and personal digital
assistants (PDAs), digital cameras, and cellular telephones.

Given that many battery-powered devices depend on batteries as a primary
power source, most battery-powered electronic devices closely monitor a charge level
remaining in the batteries in order to insure reliable operation of the device. Among
20 other things, remaining charge is used to determine a cut-off point for the batteries at
which the device automatically initiates a 'soft' shutdown. Automatic soft shutdown
helps to insure data integrity and operational reliability when batteries near an end of
useful charge. In addition, remaining charge level is also often employed by the
electronic device to give a user of the device an indication of how much operational
25 time may be available as well as warn the user of an impending or potential loss of
operational power.

Inaccuracies in battery charge level monitoring, as well as a need to insure that
shutdown occurs before the normal operation of a device is affected by loss of
sufficient battery power, often lead to an effectively artificial reduction in the

apparent charge life of a given set of batteries. Specifically, monitoring that determines a charge level of the battery to be lower than it actually is can result in a shutdown occurring sooner than it should. In addition, to insure normal operation of the device under all operating modes, the battery cut-off point is generally set conservatively based on a power requirement of an operational mode with a highest power utilization. In short, both the monitoring inaccuracies and the use of a conservative cut-off point typically result in an unnecessarily premature indication of effective end-of-charge life in many battery powered electronic devices.

Thus, it would be advantageous to be able to potentially extend a useable lifetime of a battery by improving battery charge level monitoring accuracy as well as reducing the need for unnecessarily conservative cut-off points for batteries used in battery-powered electronic devices. Such an improved monitoring accuracy and cut-off determination may extend the useful life of batteries in battery-powered electronic devices thus solving a long-standing need in the area of battery-powered devices.

15

SUMMARY OF THE INVENTION

The present invention employs an operational mode of an electronic device in one or both of battery monitoring and battery cut-off determination. In particular, mode-based monitoring, according to the present invention, employs a mode-specific or mode-determined wait period prior to performing a measurement used to determine a remaining charge level or energy level of the battery. The mode-specific wait period depends on the operational mode immediately preceding the measurement and therefore, accounts for the effects of battery recovery on measurement accuracy. Mode-based cut-off determination, according to the present invention, employs information regarding an impending mode to determine whether or not a remaining charge level or energy level in the battery is sufficient to support the impending mode. Only those operational modes for which there is sufficient remaining charge are enabled while operational modes for which there is insufficient remaining charge are disabled. Thus, whether or not the battery is cut-off depends on the impending operational mode.

30 In one aspect of the present invention, a method of mode-base monitoring of a remaining charge level of a battery used in an electronic device is provided. The

method monitors the remaining charge level after the electronic device performs an operational mode. The method comprises waiting a mode-specific period of time after the performed operational mode before determining the remaining charge level of the battery. The mode-specific period of time is based on a recovery time for the battery, the recovery time being specific to the operational mode. The mode-specific wait period of time also may be based on a chemistry of the battery in addition to mode.

In some embodiments, the method of mode-based monitoring further comprises determining the operational mode that was performed and/or performing an operational mode of the electronic device. Following the waiting period, the method may further comprise measuring a characteristic of the battery to determine a remaining charge level of the battery.

In another aspect of the present invention, a method of mode-based cut-off determination for a battery used in an electronic device is provided. The method of mode-based cut-off determination comprises determining whether a remaining charge level of the battery is insufficient to perform an operational mode. The remaining charge level is 'insufficient' when the operational mode utilizes more power or energy than that associated with the remaining charge level. In addition, whether a remaining charge level is 'insufficient' may include a determined chemistry of the battery.

In some embodiments, the method further comprises disabling operational modes for which there is insufficient remaining charge. In these and in other embodiments, the method may further comprise performing a requested operational mode if that mode is not disabled. Depending on the embodiment, the method optionally may further comprise notifying a user of the electronic device that a disabled mode has been requested.

In yet another aspect of the invention, a method of mode-based monitoring and cut-off determination of a battery used in an electronic device is provided. The method comprises waiting a mode-specific period of time after an operational mode is performed, the mode-specific period of time being based on a recovery time for the battery, the recovery time being specific to the performed operational mode. The method further comprises determining a remaining charge level of the battery after waiting the mode-specific period of time.

In another aspect of the present invention, an electronic device having mode-based battery monitoring and/or mode-based battery cut-off determination is provided. The electronic device comprises a battery, a battery monitor, a controller, a memory, and a control program stored in memory. The control program comprises instructions that, when the controller executes the control program, implement mode-based monitoring and/or mode-based cut-off determination, according to the present invention. In some embodiments of the electronic device, the instructions of the control program implement mode-based battery monitoring. In other embodiments of the electronic device, the instruction of the control program implement mode-based battery cut-off determination. In yet other embodiments of the electronic device, the instruction of the control program implement both mode-based battery monitoring and mode-based battery cut-off determination.

The present invention is applicable to all battery-powered electronic devices but is particularly useful for electronic devices that have operational modes with widely varying power utilizations and/or devices that may employ batteries having any one of a plurality of different battery chemistries. Examples of such devices include, but are not limited to, digital cameras, portable compact disk (CD) players, and portable computers. Moreover, the present invention is applicable to all battery-types or battery-chemistries. For example, the present invention works for both rechargeable type batteries and non-rechargeable type batteries.

Advantageously, the present invention provides more accurate measurements of the charge remaining in a battery used in an electronic device. Specifically, by waiting a mode-specific period of time to measure remaining charge, the present invention mitigates the deleterious effects of battery recovery on charge measurement accuracy. In essence, by waiting a mode-specific period of time following a given operation or function before measuring the charge level of the battery, a more accurate estimation of remaining charge of the battery can be made. Moreover, by improving the accuracy of measurements of remaining charge, the present invention can facilitate an effective increase in a 'useful' life of a battery by enabling the battery to be safely discharged closer to an actual end-of-life discharge condition.

Likewise, mode-based cut-off determination, according to the present invention, can extend a useful or useable life of a battery used in the electronic device. In

particular, instead of relying on a lowest common denominator to determine when a battery should be cut-off, the present invention advantageously enables some lower power modes to remain operational even when there is insufficient power or energy to enable all operational modes of the electronic device.

5 Certain embodiments of the present invention have other advantages in addition to and in lieu of the advantages described hereinabove. These and other features and advantages of the invention are detailed below with reference to the following drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

10 The various features and advantages of the present invention may be more readily understood with reference to the following detailed description taken in conjunction with the accompanying drawings, where like reference numerals designate like structural elements, and in which:

15 Figure 1 illustrates a flow chart of a method of mode-based battery charge level monitoring according to the present invention.

 Figure 2 illustrates a flow chart of a method of mode-based battery cut-off determination according to the present invention.

20 Figure 3 illustrates a flow chart of a method of mode-based battery cut-off determination and mode-based battery charge level monitoring according to the present invention.

 Figure 4 illustrates a block diagram of some embodiments of a digital camera having mode-based battery monitoring and/or mode-based battery cut-off determination according to the present invention.

25 Figure 5 illustrates an exemplary flow chart of a digital camera control program incorporating the mode-based battery charge level monitoring and mode-based battery cut-off determination of the present invention.

 Figure 6 illustrates a flow chart of an embodiment of a Check Battery function.

MODES FOR CARRYING OUT THE INVENTION

Figure 1 illustrates a flow chart of a method 100 of mode-based battery monitoring. The method 100 of mode-based battery monitoring determines a remaining charge level of or a remaining energy level in a battery used in an electronic device. The method of mode-based monitoring comprises performing 110 an operation or action of the electronic device. The operation may be any of a plurality of operations normally performed by the device. For example, in a digital camera, the operations may include, but are not limited to, capturing or recording an image, displaying an image on an image display of the camera, downloading image files from the camera to an external device, such as a personal computer (PC), and changing a zoom position of a zoom lens. In a portable compact disk (CD) player, the operations may include, but are not limited to, 'play', 'pause', 'load CD', and 'eject CD'.

The method 100 further comprises determining 120 an operational mode associated with the performed operation. As used herein, the operational mode is any operational state, or condition of the electronic device during which an operation or action of the device is performed. In general, modes are defined in a given electronic device by a way the device is used and/or an implementation of a device. In most cases, a mode is associated with, and may in fact be an action or operation of, the device. One skilled in the art is familiar with operational modes of electronic devices and can readily identify such modes for a given device.

In fact, the operational mode is generally known *a priori* from the performed 110 operation for most electronic devices. In other words, the operational mode is determined 120 by simply 'noting' which operation was performed 110. Thus, in most cases, the operation is essentially equivalent to the operational mode. For example, reviewing an image stored in memory is both an operation of a digital camera and an operational mode of the camera. As such, the terms 'operation' and 'operational mode' will be used interchangeably herein unless otherwise specified. Moreover in most electronic devices, performing 110 the operation and determining 120 the operational mode may be essentially a single, combined step. However in the general case, performing 110 the operation and determining 120 the operational mode are viewed as separate and distinct steps, for the purpose of clarity only.

the term 'mode-specific' includes embodiments that also account for the battery chemistry being used.

Moreover, the method 100 optionally may further comprise determining a chemistry of the battery being used in the device (not illustrated in Figure 1) prior to waiting the mode-specific time T_k . Determining the battery chemistry may be accomplished through an input from a user of the device or may be 'hardwired' or 'hard-coded' in the device at a time of manufacture. For example, when the user installs a battery, the device may request that the user indicate to the device which one of a set of allowed chemistries corresponds the battery just installed.

Alternatively, the device may employ a method of battery chemistry determination that directly or indirectly identifies the chemistry of the battery. For example, Bean et al., U.S. Pat. 6,215,275, incorporated herein by reference, discloses a method of battery chemistry determination or identification that utilizes a simple test circuit in conjunction with a microcontroller that measures several distinct voltages across a battery to determine battery chemistry. In another example, Bean et al., in a co-pending application entitled "A Method of Battery Chemistry Identification Through Analysis of Voltage Behavior", Serial No. 09/859,015, which was filed May 14, 2001 and is incorporated herein by reference, disclose several *in situ* measurements of battery voltages under various loaded and unloaded battery conditions for battery chemistry determination. The described and cited methods, as well as any other method that one skilled in the art might devise to determine battery chemistry of a battery used in the electronic device, are each within the scope of the present invention.

In general, determining battery chemistry need be performed only once, e.g., immediately following replacement of the battery in the device. However, it is within the scope of the present invention to perform battery chemistry determination multiple times for each replaced battery as well. The determined chemistry is employed to determine the mode-specific wait time T_k along with mode.

Following waiting 130, the method 100 may further comprise measuring 140 a characteristic of the battery to determine a remaining charge level of the battery. For example, a voltage of the battery may be measured 140 to determine the remaining charge level of the battery. Advantageously, since the measurement 140 is performed

following the mode-specific wait time T_k , the measurement is largely free of errors that may have been introduced in such a measurement due to the recovery of the battery.

In another aspect of the present invention, a method 200 of mode-based cut-off determination of a battery used in an electronic device is provided. Figure 2 illustrates a flow chart of the method 200 of mode-based cut-off determination according to the present invention. As used herein, the term 'cut-off' or 'cut-off point' refers to a point in a discharge profile of the battery at which there is insufficient power to operate the device. Generally, the cut-off determination is made by the electronic device based on a measurement or measurements of the remaining battery charge. Conventionally, the device performs a soft shut-down or enters a standby mode when the cut-off point is reached.

The method 200 of mode-based cut-off determination comprises determining ~~210 a remaining charge level of the battery. Determining 210 the remaining charge~~ level may comprise measuring a characteristic of the battery, such as a battery voltage and computing a remaining charge level. For example, the remaining charge level may be computed using a look-up table or a similar method that relates the remaining charge level to the measured battery voltage. One of ordinary skill in the art is familiar with a variety of methods of determining 210 the remaining charge level on a battery from measurements of characteristics of the battery. All such methods for determining 210 the remaining charge level of a battery in an electronic device are within the scope of the present invention.

In particular, in a preferred embodiment of the present invention, the remaining charge level is determined 210 by measuring a voltage of the battery. The measured voltage is then compared to voltages in a look-up table or on a curve of voltage with respect to remaining charge on the battery. From the comparison, a remaining charge value corresponding to the measured voltage indicates the remaining charge level in the battery.

In some embodiments, the method 200 optionally may further comprise determining a chemistry of the battery (not illustrated in Figure 2) at some point prior to determining 210 the remaining charge level. Batteries based on different chemistries are known to have different amounts of remaining power or energy at

different points in their respective discharge profiles wherein the points are each indicated by a measurement of a particular characteristic of the battery, such as voltage. The determined chemistry of the battery may be employed to modify the determination 210 of remaining charge level. For example, if a voltage is measured
5 and compared to a look-up table or curve to determine remaining charge level, the determined chemistry may be employed to select a look-up table or curve corresponding to the determined chemistry from among a set of such look-up tables or curves for various chemistries.

The method 200 further comprises disabling 220 operational modes for which
10 there is insufficient remaining charge. Equivalently, an operational mode may be disabled 220 if the charge remaining is insufficient to produce a minimum voltage necessary for the mode, given the load attributed to the mode. Insufficient remaining charge means that the operational mode utilizes more power than that which remains. Thus, given information regarding which modes are available in the device, a
15 corresponding minimum remaining charge level necessary for normal operation of each mode may be readily determined. From the corresponding minimum remaining charge level, a determination can readily be made whether a given mode can operate properly, given the determined 210 remaining charge level. In short, if the determined 210 remaining charge level is insufficient for a given mode, the mode is
20 disabled 220.

For example, a particular mode, such as an image capture mode in a digital camera, may have a minimum voltage level for normal operation. Without the minimum voltage, the camera may not reliably perform the image capture. In other words, if the determined 210 remaining charge level of the battery equates to a battery
25 voltage that is less than the minimum voltage level for the normal image capture mode operation, then the image capture mode may not operate properly if requested by the user. Therefore, such a mode is disabled 220, according to the present invention.

An operational mode may be disabled 220 in a variety of ways, all of which are
30 generally dependent on a specific electronic device and the implementation of the mode in the device. For example, in some electronic devices, a software flag may be set to indicate that a given mode is disabled 220. In other electronic devices, a

hardware-based logic line may be asserted to disable 220 a given operational mode, for example. One of ordinary skill in the art may readily devise an assortment of different approaches to disabling a mode in a particular electronic device, all of which are within the scope of the present invention.

5 The method 200 further comprises performing 230 a requested operational mode if that mode is not disabled 220. Thus, if the user of the electronic device requests a particular operational mode in a manner consistent with the electronic device, the mode is performed 230, if and only if the requested mode is not disabled 220. A decision tree or similar approach may be used to implement such a sequence of
10 disabling 220 and performing 230 steps using flags, for example.

For example, if a software flag is used in the electronic device to identify a disabled function, the flag associated with a requested operational mode is 'tested' to see whether or not that flag is set. In this example, if the flag is set indicating that the
mode is disabled 220, the operational mode is not performed 230. If the flag is not
15 set, the operational mode is performed 230 in a normal manner.

The method 200 further comprises optionally notifying 240 the user of the electronic device that a requested mode has been disabled. For example, with a digital camera, a 'Low Bat' icon may be illuminated on a status display if a requested operational mode is disabled 220. Alternatively, the user may be notified 240 by
20 displaying a message to the user. The displayed message may inform the user that the requested operational mode is not available due to lack of power, for example. A combination of illuminating a 'Low Bat' icon and displaying a message may also be employed. In yet another example of notification 240, a list of enabled and/or disabled operational modes may be provided to the user by way of one of the displays
25 available on the device.

In yet another aspect of the present invention, a method 300 of mode-based monitoring and mode-based cut-off determination for a battery powered electronic device is provided. A flow chart of the method 300 of mode-based monitoring and mode-based cut-off determination is illustrated in Figure 3. The method 300
30 essentially combines aspects of the method 100 and method 200 of the present invention.

The method 300 comprises determining 310 a remaining charge level of a battery. The method 300 further comprises disabling 320 a mode for which there is insufficient power for proper operation. The method 300 further comprises performing 330 a mode if the mode has not been disabled 320. The method 300 further comprises waiting 340 a mode-specific wait time T_k corresponding to the performed 330 mode after the mode is performed 330. Waiting 340 the mode-specific wait time T_k occurs at an end of the performed 330 mode. After waiting 340 the mode-specific wait time T_k , the method 300 may be repeated starting at determining 310.

10 In yet another aspect of the present invention, an electronic device 400 having mode-based battery monitoring and/or mode-based battery cut-off determination is provided. Figure 4 illustrates a block diagram of the electronic device 400. The electronic device 400 comprises a battery 410, a battery monitor 420, a controller 430, a memory 440, and a control program 450 stored in the memory 440. The control
15 program 450 comprises a set of instructions. The battery monitor 420 measures a characteristic of the battery 410 and communicates a measured result to the controller 430 to provide battery monitoring. The controller 430 executes the control program 450, the instructions of which implement mode-based monitoring and/or mode-based cut-off determination, according to the present invention, in part using the measured
20 result.

In some embodiments of the electronic device 400, the instructions of the control program 450 implement mode-based battery monitoring. In particular, the instructions of the control program 450 perform an operation of the electronic device and determine an operational mode associated with the performed function. The
25 instructions further wait a mode-specific period of time following an end of the operation. The mode-specific wait time is associated with the determined operational mode and preferably, is based on the recovery time of the battery, as described hereinabove. In addition, as described hereinabove with respect to method 100, the mode-specific period of time may be both 'mode-specific' and battery 'chemistry-specific'. In other words, different mode-specific wait times may be employed to
30 account for different chemistries of the battery 410. Following the waiting period, the instructions may further measure a characteristic of the battery to determine a

remaining charge level of the battery. In a preferred embodiment, the control program 450 implements the method 100 of mode-based monitoring of the present invention.

5 In other embodiments of the electronic device 400', the instruction of the control program 450' implement mode-based battery cut-off determination according to the present invention. The instructions of the control program 450' determine a remaining charge level of the battery and disable operational modes for which there is insufficient remaining charge. The instructions enable a requested operational mode to be performed if that mode is not a disabled. The instructions optionally may
10 notifying a user of the electronic device that a disabled mode has been requested, or provide a list of disabled modes and/or a list of enabled modes that is displayed for the user to view. In a preferred embodiment, the control program 450' implements the method 200 of mode-based battery cut-off determination of the present invention.

----- In yet other embodiments of the electronic device 400", the instructions of the
15 control program 450" implement both mode-based monitoring and mode-based battery cut-off determination. Specifically, the instructions of the control program 450" determine a remaining charge level of a battery and disable a mode for which there is insufficient power for proper operation. The instructions further enable a mode to be performed if the mode has not been disabled and the user selects the non-
20 disabled mode. The instruction further implement waiting a mode-specific wait time T_k corresponding to the performed mode after the performed mode has ended. After waiting the mode-specific wait time T_k , the instructions may repeat the mode-based monitoring and cutoff determination of the battery starting at determining a remaining charge level. In a preferred embodiment, the control program 450" implements the
25 method 300 of mode-based monitoring and mode based battery cut-off determination.

To better understand the present invention, consider the following example of the electronic device 400" in the form of a digital camera. The digital camera 400" provides mode-based monitoring and mode-based cut-off determination of a battery 410 installed in the digital camera 400" through execution of a control program 450"
30 by the controller 430. The description hereinbelow of the digital camera 400" is exemplary only and is not intended to limit the scope of the present invention. The battery monitor 420 of the example camera 400" measures a battery voltage of the

battery 410. The controller 430 utilizes the measured battery voltage to determine a charge remaining in the battery 410.

Furthermore, for the purposes of the discussion of this example and in no way by limitation, the camera 400" is assumed to have four operational modes. The four exemplary modes are referred to hereinbelow as 'review' mode, 'capture' mode, 'PC' mode, and 'view' mode. Thus, mode 1 is review mode, mode 2 is capture mode, mode 3 is PC mode, and mode 4 is view mode. The review mode in the example camera 400" requires a minimum battery voltage V_{review} to operate properly. Similarly, to operate reliably, the capture mode needs a minimum battery voltage $V_{capture}$, the PC mode needs a minimum battery voltage V_{PC} , and the view mode requires a minimum battery voltage V_{view} . For the purposes of discussion, the $V_{capture}$ is greater than the V_{review} . Similarly, the V_{review} is greater than the V_{view} , and the V_{view} is greater than the V_{PC} . Moreover, wait times have been determined for each of these modes of the example camera 400". The wait time T_k for the review mode is T_{review} while the wait time for the capture mode is $T_{capture}$. The wait time for the PC mode is T_{PC} and the wait time for the view mode is T_{view} .

Figure 5 illustrates a flow chart of a portion of a control program 450" used to implement the mode-based monitoring and mode-based cut-off determination for the battery 410 in the example camera 400". Flags having the name of a corresponding mode are used in the program 450" to indicate whether the mode is enabled (e.g., Flag = 1) or disabled (e.g., Flag = 0). For example, if the review mode is disabled, the flag *Review* is set to '0'. Similarly, if the view mode is enabled, the flag *View* is set to '1'. A variable of the program 450" called 'Last State' is used to indicate which of the modes was performed. The variable *Last State* (*LS*) indicates the performed mode using a number corresponding to the mode. Thus, the *LS* set to '3' indicates that the PC mode was performed while the *LS* set to '1' indicates that the review mode was performed. The *LS* set to '0' indicates no performed mode and is used for initialization purposes. A variable *Mode* is used to store a number (i.e., 0 - 5) indicating which mode has been requested by the user of the camera 400". The variable *Mode* equal to '5' is used to indicate a request to shutdown and turn off power to the camera 400". For clarity, the flow chart illustrated in Figure 5 omits

details not directly associated with implementing the mode-based monitoring and mode-based cut-off determination for the example camera 400".

Referring to Figure 5, the control program 450" begins at a Power On 502 operation. During the Power On 502 operation, power is applied to the electronics of the camera 400" and various components thereof are initialized. The Power On 502 operation is followed by an Initialize Flags 504 operation, wherein the various mode flags are initialized to '1' and the *LS* variable and the *Mode* variable are both initialized to '0'. In addition, the wait time T_k is initialized to '0'. A mode requested by the user is determined by an Input Request 506 and the *Mode* variable is assigned a number corresponding to the requested mode (i.e., *Mode* = 1, 2, 3, 4 or 5). Then a Function Call 508 is made to a Check Battery function.

Figure 6 illustrates a flow chart of an embodiment of the Check Battery function 600. In the Check Battery 600 function, a Wait 602 causes the function to wait for T_k seconds following which a Measure Voltage 604 causes the battery monitor 420 to measure a battery voltage V_{bat} for the battery 410. The measured battery voltage V_{bat} is compared to the minimum voltage V_{PC} needed by the PC mode in a first Decision block 606 of the Check Battery function 600. If the voltage V_{bat} is not greater than the voltage V_{PC} then a message is displayed to the user indicating that there is insufficient operating power by a Message block 608, and a Power Off 610 initiates a shutdown that ultimately shuts off power to the camera 400".

On the other hand, if the voltage V_{bat} is greater than the voltage V_{PC} , a second Decision block 612 of the Check Battery function 600 compares the voltage V_{bat} to the minimum voltage V_{view} for the view mode. If the voltage V_{bat} is not greater than the voltage V_{view} , the *View* flag is set to '0' in a first Set block 614 indicating insufficient voltage for the view mode. A third Decision block 616 of the Check Battery function 600 compares the voltage V_{bat} to the minimum voltage V_{review} for the review mode. If the voltage V_{bat} is not greater than the voltage V_{review} , the *Review* flag is set to '0' in a second Set block 618 indicating insufficient voltage for the review mode. A fourth Decision block 620 of the Check Battery function 600 compares the voltage V_{bat} to the minimum voltage $V_{capture}$ for the capture mode. If the voltage V_{bat} is not greater than the voltage $V_{capture}$, the *Capture* flag is set to '0' in a third Set block 622 indicating insufficient voltage for the capture mode. A second Message block 624 of the Check

Battery function 600 displays which of the modes are available and which modes are disabled. The Check Battery function 600 ends with a Return block 626 that returns to the control program 450".

Referring again to Figure 5, upon returning to the control program 450" from
5 the Check Battery function 600, a first Decision block 510 of the control program 450" checks the requested mode and the *Capture* flag. If the *Mode* variable equals '2' and the *Capture* flag equals '1', indicating that capture mode is requested and enabled, the capture mode is performed 512, the *LS* flag is set 514 to '2', and the wait time T_k is set 516 to equal to $T_{capture}$. The program 450" then loops back to the Input
10 Request block 506. If the *Mode* variable is not equal to '2' and/or the *Capture* flag equals '0', the program 450" continues to a second Decision block 520.

The second Decision block 520 of the control program 450" checks the requested mode. If the *Mode* variable is equal to '5', indicating a request for
shutdown, then the Power Off 522 is performed to shut down the camera 400". After
15 the Power Off 522 is complete, the program 450" ends 524. If the *Mode* variable is not equal to '5', then the program 450" proceeds to a third Decision block 530.

The third Decision block 530 of the control program 450" checks the requested mode and the *Review* flag. If the *Mode* variable equals '1' and the *Review* flag equals
'1', the review mode is performed 532, the *LS* flag is set 534 to '1', and the wait time
20 T_k is set 536 to equal to T_{review} . The program 450" then loops back to the Input Request 506. If the *Mode* variable is not equal to '1' and/or the *Review* flag equals '0', the program 450" continues to a fourth Decision block 540.

The fourth Decision block 540 of the control program 450" checks the requested mode and the *PC* flag. If the *Mode* variable equals '3' and the *PC* flag equals '1', the
25 PC mode is performed 542, the *LS* flag is set 544 to '3', and the wait time T_k is set 546 to equal to T_{PC} . The program 450" then loops back to the Input Request 506. If the *Mode* variable is not equal to '3' and/or the *PC* flag equals '0', the program 450" continues to a fifth Decision block 550.

The fifth Decision block 550 of the control program 450" checks the requested
30 mode and the *View* flag. If the *Mode* variable equals '4' and the *View* flag equals '1', the view mode is performed 552, the *LS* flag is set 554 to '4', and the wait time T_k is

set 556 to equal to T_{view} . The program 450" then loops back to the Input Request 506. If the *Mode* variable is not equal to '4' and/or the *View* flag equals '0', the program 450" simply loops back to the Input Request 506.

In the manner described in this example, the control program 450", when
5 executed by the controller 430, uses the battery monitor 420 to determine whether or
not there is enough voltage available from the battery 410 to perform each of the
modes of the camera 400" prior to executing any of the modes. The determination is
repeated after each mode. Moreover, the program 450" adjusts the wait time T_k after
each time a mode is performed, such that the wait time T_k corresponds to the
10 respective mode-specific wait time of the performed mode. Thus, when the battery is
again monitored, the wait time T_k is the mode-specific wait time. Given the
discussion and example hereinabove, one of ordinary skill can readily construct the
control program 450, 450', 450" using any standard computer programming language
or construct.

15 Thus, there have been described methods 100, 200, 300 that provide mode-
based monitoring and/or mode-based cut-off determination of a battery in an
electronic device. In addition, an electronic device 400, 400', 400" having mode-
based battery monitoring and/or mode-based battery cut-off determination has been
described. It should be understood that the above-described embodiments are merely
20 illustrative of the some of the many specific embodiments that represent the principles
of the present invention. Clearly, those skilled in the art can readily devise numerous
other arrangements without departing from the scope of the present invention.

What is claimed is:

1. An electronic device 400, 400', 400" having a plurality of operational modes and obtaining at least some power from a battery, the device comprising:
 - a battery monitor 420 that measures a characteristic of a battery installed in the electronic device;
 - a memory 440;
 - a control program 450, 450', 450" stored in the memory 440, the control program 450, 450', 450" comprising a set of instructions; and
 - a controller 430, the controller 430 executing the control program 450, 450', 450", the control program, when executed by the controller, implementing mode-based battery charge level monitoring 100, 200, 300, wherein a remaining charge level is determined one or both of before and after an operational mode is performed.
2. The electronic device 400', 400" of Claim 1, wherein the set of instructions of the control program 450', 450" comprises:
 - determining 210, 310 the remaining charge level of the battery before an operational mode is performed to determine whether the remaining charge level is insufficient to perform the operational mode, the remaining charge level being insufficient when the operational mode utilizes more power than that associated with the determined remaining charge level.
3. The electronic device 400', 400" of Claim 1-2, wherein the set of instructions of the control program 450', 450" further comprises:
 - disabling 220, 320 any operational mode of the device for which the determined remaining charge level of the battery is insufficient to perform.
4. The electronic device 400, 400', 400" of any of Claims 1-3, wherein the set of instructions of the control program 450, 450', 450" further comprises:
 - performing 110, 230, 330 a requested operational mode if the requested operational mode has not been disabled;

instructions of the control program 450, 450' comprises:

waiting 130, 340 a mode-specific period of time after an operational mode is performed before determining the battery charge level remaining on the battery, the mode-specific period of time being based on a recovery time for the battery, the recovery time being specific to the performed operational mode.

6. The electronic device 400, 400" of Claim 5, wherein waiting 130, 340 a mode-specific period of time comprises:

determining 120 the operational mode that was performed, each determined operational mode having an associated power consumption, the recovery time being based on the power consumption.

7. The electronic device 400, 400" of any of Claim 5-6, wherein waiting 130, 340 a mode-specific period of time comprises:

determining a load experienced by the battery while the operational mode is performed, the recovery time being associated with the load, the recovery time being a time for the battery to recover from the load.

8. The electronic device 400', 400" of any of Claims 3-7, wherein the set of instructions further comprises:

notifying 240 a user of the device of any disabled operational modes comprising one or more of displaying the disabled operational mode on a status display of the electronic device, displaying one or both of a list of disabled operational modes and a list of enabled operational modes on the status display, and using a 'Low Bat' display for each disabled operational mode.

9. The electronic device 400, 400', 400" of any of Claims 1-8, wherein determining 210, 310 the remaining charge level of the battery comprises:

measuring 140 a characteristic of the battery with the battery monitor, the battery monitor communicating the measured battery characteristic to the controller; and

computing a remaining charge from the measured battery characteristic.

That element is used in the process of determining the remaining charge level of the battery prior to determining 210, 310 the remaining charge level of the battery.

Application No: GB 0307412.7
Claims searched: 1 to 10

Examiner: Ian Rees
Date of search: 14 July 2003

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance	
X, Y	X: 1 to 5, 9 Y: 10	US 3979657	YORKSIE. See column 1 (line 18) to column 2 (line 7).
X, Y	X: 1, 2, 5, 9 Y: 10	US 5798702	OKAMOTO. See column 10 (line 53) to column 11 (line 22).
X, Y	X: 1, 2, 5, 9 Y: 10	US 4994728	SASAKI. See column 1 (line 60) to column 2 (line 5).
X, Y	X: 1, 2, 9 Y: 10	US 6046574	BARANOWSKI. See column 3 (line 54) to column 4 (line 35).
X, Y	X: 1, 2, 9 Y: 10	EP 0592965 A2	SANYO. See column 3 (line 31) to column 5 (line 3).
X, Y	X: 1, 2, 9 Y: 10	US 6134457	HA. See column 2 (line 56) to column 3 (line 5).
X, Y	X: 1, 2, 9 Y: 10	US 5317362	TAKAHASHI. See column 4 (line 50) to column 5 (line 17).
Y	10	US 6215275 B1	BEAN. See whole document.
A	5	US 5352982	NAKAZAWA. See claim 1.

Categories:

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&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKCV:

G1U

Worldwide search of patent documents classified in the following areas of the IPC⁷:

Application No: GB 0307412.7
Claims searched: 1 to 10

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Date of search: 14 July 2003

G01R

The following online and other databases have been used in the preparation of this search report:

EPODOC, WPI, PAJ

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